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Thanks for all your help. Darren

Impacts of Shorebirds on Macroinvertebrates in the Lower Mississippi Alluvial Valley

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ABSTRACT.—Shorebirds use stopover sites throughout the Lower Mississippi Alluvial Valley (LMAV) to fuel their southern migration. At these stopover sites shorebirds exploit macroinvertebrates as their primary foraging material during migration. Studies from coastal areas suggest that shorebirds can significantly deplete macroinvertebrate abundance and biomass at stopover sites. Whether these results are true for the LMAV remains to be evaluated. An exclosure experiment was conducted on five National Wildlife Refuges (NWRs) stretching 400 km throughout the LMAV to see if shorebird foraging impacted macroinvertebrate community composition, abundance and standing stock biomass. Macroinvertebrates were sampled in the late summer of 2001 and 2002 from exclosure areas and open areas and compared using 2-sample paired *t*-tests. Community composition was relatively similar between the five refuges sampled. Macroinvertebrate abundances ranged from 300 to 433,000 individuals/m^2 with a mean of 66,500 ($\pm$6000) individuals/m^2.

Shorebird foraging had no significant impact on abundance. Macroinvertebrate biomass ranged from less than 0.1 to greater than 24.4 g ash free dry mass (AFDM)/m^2 with a mean of 3.43 ($\pm$0.35) g AFDM/m^2. With the exception of one sampling date, 21 August 2001 at Bald Knob NWR, shorebird foraging did not significantly impact macroinvertebrate biomass. On the exceptional date, the difference was due to a reduction of Chironomidae larvae, which was neither the most abundant macroinvertebrate present nor the macroinvertebrate comprising the highest biomass. Results of this study suggest that, at present, shorebirds do not have a significant impact on foraging material in the LMAV flyway during their southern migration. However, with continued degradation to other interior regions and increased promotion of shorebird management in the LMAV, the potential exists for shorebirds to increase in numbers high enough to cause significant impacts in the future.

INTRODUCTION

Shorebirds migrate from their northern summer breeding grounds in North America to their wintering grounds in Central and South America. Primary migration routes, which trace both coastlines and interior regions, provide corridors of travel, resting habitat and foraging habitat for migrating populations (Helmers, 1992). The greatest shorebird management objective within the Lower Mississippi River Valley (LMAV) is to provide productive shallow water and mudflat habitats where shorebirds can forage on their primary food source, aquatic macroinvertebrates (Loesh *et al.*, 2000).

Migratory shorebirds in the LMAV prefer highly productive stopover sites where foraging on macroinvertebrates can increase shorebird body mass by up to 100% (Mihuc *et al.*, 1997; Elliot and McKnight, 2000). Migratory populations exhibit impressive site fidelity, returning to these productive sites year after year (Haymen *et al.*, 1986). Thus, the ability of these areas to provide adequate and sustainable resources in the form of aquatic macroinvertebrate biomass is a key feature of successful shorebird management (Helmers, 1992; Brown *et al.*,

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1997). Yet, little is known about what conditions best promote macroinvertebrate biomass and what the relative impact of shorebird foraging is on macroinvertebrate communities at stopover sites in the LMAV.

Concentrated foraging at highly productive stopover sites suggests that high densities of shorebirds can significantly alter macroinvertebrate prey populations (Szekely and Bamberger, 1992). Most studies focusing on the impacts foraging shorebirds have on macroinvertebrate communities have been conducted along coastal migration routes that support very large (*e.g.*, 4500 shorebirds/ha) migratory populations (Goss-Custard, 1977; Quammen, 1981; Hicklin and Smith, 1984; Goss-Custard *et al.*, 1991; Colwell and Landrum, 1993; Yates *et al.*, 1993; Rehfisch, 1994; Backwell *et al.*, 1998). Along these coastal flyways, shorebird foraging has been shown to significantly reduce macroinvertebrate abundance and biomass (Schneider, 1978; Schneider and Harrington, 1981; Quammen, 1984; Mercier and McNeil, 1994; Weber and Haig, 1997). In contrast, very little is known about the effect of shorebird foraging on inland sites (Szekely and Bamberger, 1992). In the upper northwestern portions of the Mississippi River flyway, late summer migrating shorebirds are not as concentrated and do not significantly affect macroinvertebrate biomass in managed habitats (Mihuc *et al.*, 1997). If these birds concentrate in the southern portions of the flyway, the potential exists that densities may be high enough to impact macroinvertebrate biomass in the LMAV.

In addition, mid-continent shorebird habitats along the Texas high plains have been negatively impacted by the introduction of agriculture. Continued degradation of these interior regions may result in shorebirds switching away from other interior routes to routes such as the Mississippi Flyway (Rottenborn, 1996; Skagen, 1999; Smart and Gill, 2003). Such a shift may be another factor that could increase foraging impacts on shorebird habitats of the LMAV.

Macroinvertebrate abundance and biomass are more associated with hydrophytes and organic detritus, which serve as foraging material and cover (Reid, 1985; Braccia and Batzer, 2001) rather than with open water sites with no standing vegetation (Voigts, 1976). Helmers (1992) suggested providing detritus in managed impoundments as a means of increasing macroinvertebrate biomass. However, no studies have been conducted in the LMAV to test whether or not a correlation exists between substrate organic matter and macroinvertebrate biomass.

Historically, the bottomland hardwood forests that once dominated the LMAV were not high quality shorebird stopover sites (Twedt *et al.*, 1998) and foraging habitat was limited to mudbars, sandbars and drying oxbows directly associated with major river systems (Elliot and McKnight, 2000). Hydrologic alterations to mainstem rivers have reduced these habitats; however, agricultural related practices have resulted in clearing 75% of the bottomland hardwood forest in the LMAV. These alterations have provided shorebirds with flooded agricultural fields, aquaculture ponds and managed impoundments, likely resulting in an overall increase in available foraging habitat (Mihuc *et al.*, 1997; Elliot and McKnight, 2000).

The objective of this study was to assess macroinvertebrate community composition, abundance and biomass associated with habitats in the LMAV specifically managed to support migratory shorebird populations. Specific objectives were to: (1) determine if a correlation exists between substrate organic matter and macroinvertebrate biomass and (2) test if foraging by migratory shorebird populations significantly impacts macroinvertebrate community composition, abundance and biomass in the LMAV.

METHODS

Study areas.—We conducted this study at five National Wildlife Refuges (NWRs) stretching 400 km along the LMAV within three states (Fig. 1). These refuges were chosen because they

TABLE 1.—National Wildlife Refuges sampled including year sampling took place, number of impoundments sampled, impoundment size, number of plots established and number of plots sampled

Site	Year	# of impoundments sampled	Impoundment size (ha)	# of plots established	# of plots sampled
Hatchie NWR	2001	1	0.5	10	10
Bald Knob NWR	2001	1	6	20	10*
Bald Knob NWR	2002	1	40	25	18
Morgan Break NWR	2002	2	7, 7	30	16
Yazoo NWR	2002	2	9, 7	28	13
St. Catherine Creek NWR	2002	1	0.5	10	5

* Ten of the twenty plots at Bald Knob NWR in 2001 were sampled twice. No other plots were sampled more than once

of 2002, a 40-ha impoundment was sampled. Flooding and draw-down schedules were identical to those in 2001.

Morgan Brake NWR is a 3000-ha refuge located on the eastern edge of the Mississippi Alluvial Plain and is bordered by loessal bluffs. Using 27 impoundments that were once used for catfish aquaculture, Morgan Brake provides nesting, resting and feeding habitat for waterfowl and other migratory birds. Sampling was conducted during the late summer migration of 2002 in two 7-ha impoundments where water levels were reduced to provide foraging habitat for shorebirds.

Similar to Morgan Brake, the 5240-ha Yazoo NWR manages abandoned catfish impoundments to provide habitat for migratory waterbirds. Four impoundments were managed specifically for shorebirds during late summer and early Fall 2002. These impoundments were flooded in October and November 2000 and remained flooded as waterfowl resting habitat until 2002. In late Summer of 2002, water levels were slowly reduced to provide foraging habitat for shorebirds. Of these four impoundments, only two, a 9-ha impoundment and a 7-ha impoundment were sampled as part of this study.

St. Catherine Creek NWR is a 9900-ha area with many depressions and basins in low areas that flood naturally and provide optimal habitat for wintering waterfowl. Smaller basins tend to dry out in late summer and provide foraging habitat for shorebirds with minimal management. One 0.5-ha basin was identified and sampled during late summer migration of 2002 as part of this study.

Field methods.—We sampled in late summer of 2001 and 2002 on dates that corresponded with peak migration times of shorebirds through the LMAV (Table 1; Helmers, 1992). A series of replicated study plots within managed habitats was used to quantify changes in macroinvertebrate community in response to shorebird foraging.

All study plots were established before shorebird foraging began. The plots consisted of two 1 × 2 m areas defined by four wooden posts. The exclosure area was covered on the top and sides by 5-cm mesh nylon netting to exclude shorebirds, but allowed macroinvertebrate movement. The netting was draped over the wooden posts to a height of 15 cm above the substrate. Four additional posts were used to define a nearby (*i.e.*, ca. 15 m away) 1 × 2 m reference location with a similar water regime as the exclosure area. A total of 113 plots was established across the five NWRs, but all plots were not sampled. Because shorebird management plans call for the slow reduction of water levels during the migratory period (Helmers, 1992), not all plots were within the optimal sampling range during each sampling period.

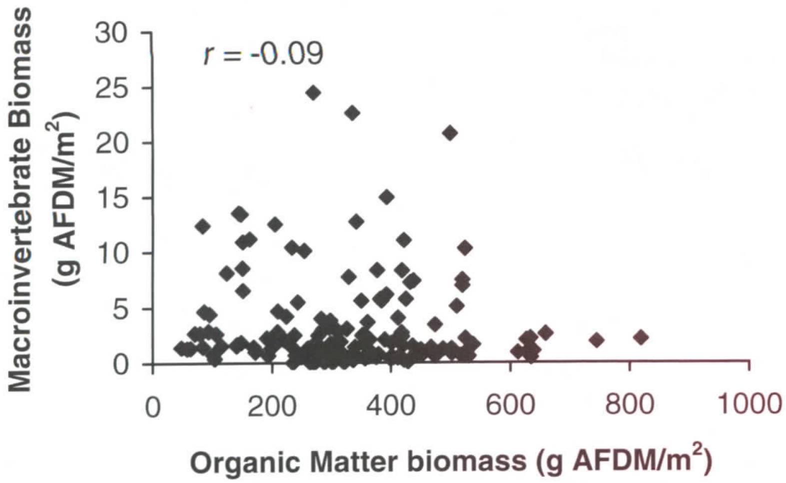

FIG. 2.—Correlation between macroinvertebrate biomass and substrate organic matter sampled from managed shorebird impoundments on five national wildlife refuges in the LMAV

Biomass.—Biomass ranged from less than 0.1 (Hatchie NWR) to greater than 24.4 g AFDM/m^2 (Yazoo NWR), with a mean overall biomass of 3.43 ($\pm$0.35) g AFDM/m^2 across all 5 refuges (Fig. 4). During the 2001 sampling at Bald Knob NWR, biomass was significantly greater in exclosures than in open areas. No significant difference was seen for that year at Hatchie NWR, nor at any of the refuges in 2002 (Fig. 4).

Impoundments with heaviest shorebird usage during the study were: (1) Yazoo NWR (156 shorebirds/ha, Sept. 2002), (2) Bald Knob NWR (133 shorebirds/ha, August 2001), (3) August 2002 at Bald Knob NWR (43 shorebirds/ha) and 20 August 2002 at Bald Knob NWR (35 shorebirds/ha, Fig. 5). Except for 21 August 2001 at Bald Knob, no significant differences were found in biomass between open and exclosure areas.

On 21 August 2001 at Bald Knob, biomass was dominated by the beetle larva *Berosus* sp., chironomids and oligochaetes. Of these three taxa, only chironomid biomass was significantly reduced in open areas (Fig. 6). No significant reductions were noted in any of the other taxa. Similarly, no significant differences were noted for chironomids on any other sampling date.

DISCUSSION

The lack of a correlation between substrate organic matter and macroinvertebrate biomass suggests that factors other than organic matter availability (*e.g.*, flooding periodicity and temperature) may influence macroinvertebrate biomass at these sites (Helmers, 1992; Twedt *et al.*, 1998). Thus, enhancement of organic matter in these impoundments is unlikely to increase macroinvertebrate availability to foraging shorebirds. Furthermore, organic matter additions might actually be counter productive for shorebird management since shorebirds tend to avoid areas with too much standing vegetation (Twedt *et al.*, 1998).

Foraging material for migrating shorebirds are highly variable an unpredictable in interior regions where wetlands have variable water regimes (Davis and Smith, 2001). However, macroinvertebrate community composition of the agriculture fields, aquaculture ponds and managed impoundments sampled on the five NWRs was relatively consistent

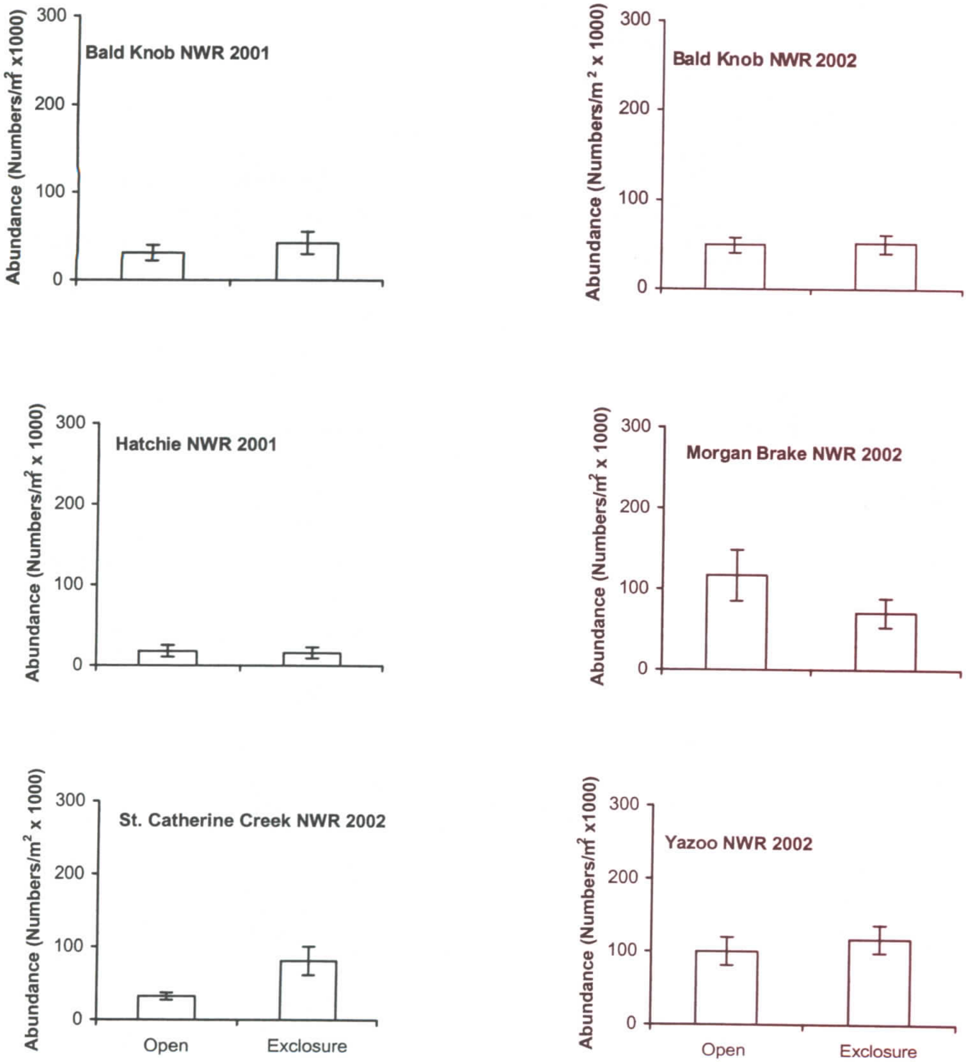

FIG. 3.—Mean macroinvertebrate abundances (±standard error) in open and exclosure areas at each of the NWRs for both sampling seasons. No significant differences were found between open and exclosure areas ($P < 0.05$)

but similar to those reported for other sites in the LMAV (46,000–84,000 individuals/m^2, Augustin *et al.*, 1999).

Because of the wide range of body sizes and nutritional content, abundance can be a poor indicator of macroinvertebrate resource availability to higher trophic levels (Grubaugh *et al.*, 1996). Managers concerned with providing foraging resources for shorebirds should be more focused on macroinvertebrate biomass than abundance as a measure of resource availability (Loesch *et al.*, 2000).

Timing and duration of flood regime plays a critical role in colonization and production

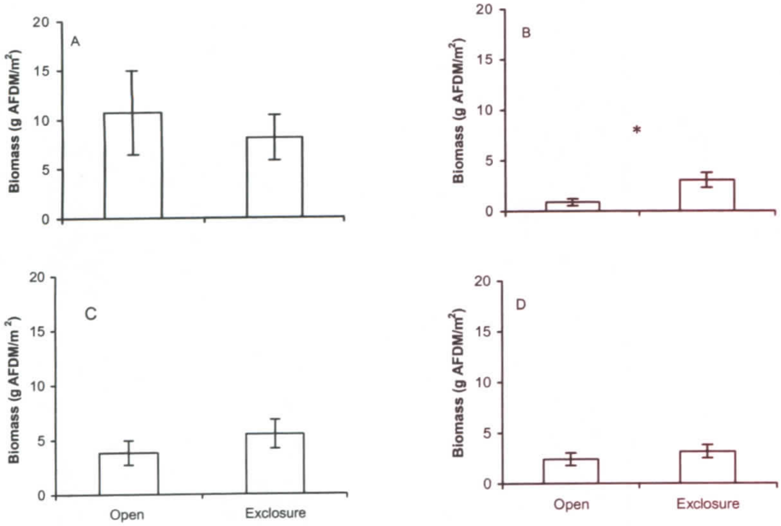

FIG. 5.—Mean biomass (±standard error) of macroinvertebrates on the four sample dates with the highest shorebird activity. A) 5 September 2002 Yazoo NWR 156 shorebirds/ha. B) 21 August 2001 Bald Knob NWR 133 shorebirds/ha. C) 28 August 2002 Bald Knob NWR 43 shorebrids/ha. D) 20 August 2002 Bald Knob NWR 35 shorebirds/ha. Asterisk indicates significant difference between open and exclosure areas ($P < 0.05$)

shorebird foraging on macroinvertebrate biomass in the LMAV may be due to lower densities of shorebirds migrating through the LMAV than in coastal habitats where impacts have been documented (Schneider, 1978; Schneider and Harrington, 1981; Quammen, 1984; Mercier and McNeil, 1994; Weber and Haig, 1997). It is important to note that shorebird densities in coastal areas can reach 4500 birds/ha (Mercier and McNeil, 1994), which is over 28 times the density recorded during the present study. The United States Shorebird Conservation Plan states that densities of 42 birds/ha constitutes very high concentration for the LMAV (Elliot and McKnight, 2000).

Impoundments with higher macroinvertebrate biomass may be less likely to be significantly impacted by shorebird foraging than impoundments with less macroinvertebrate biomass. During the 2001 sampling season at Bald Knob, for instance, relative shorebird density was the second highest reported during the study (133 shorebirds/ha). Average macroinvertebrate biomass inside the exclosure areas was 3.1 g AFDM/m^2 and a significant impact on the biomass occurred. However, shorebird densities were higher on 5 September 2002 at Yazoo NWR (156 shorebirds/ha) and average macroinvertebrate biomass inside the exclosures was 8.0 g AFDM/m^2, but no impact occurred (Fig. 5).

One of the goals of the Lower Mississippi Valley Joint Venture is to provide 2000 ha of shorebird habitat for 500,000 shorebirds, which would result in a relative density of 250 shorebirds/ha in the LMAV (Loesh *et al.*, 2000). While we only saw one instance where foraging significantly impacted macroinvertebrate biomass, relative foraging densities during this study never exceeded 156 shorebirds/ha. Our study suggests that if migrating shorebird populations along the LMAV increase, either due to intrinsic growth or shorebirds switching from other interior flyways (Skagen *et al.*, 1999; Smart and Gill, 2003), foraging impacts may result in significant reductions in the availability of macroinvertebrate biomass in these sites.

(1998) observed that shorebird prey behavior can affect the prey that are taken by shorebirds. This has implications on macroinvertebrate resource availability throughout the migration period. Specifically, if earlier migrants are foraging primarily on easily encountered taxa, this might make foraging a more difficult process for later season migrants.

If proposed management goals for shorebirds are met throughout the LMAV, shorebird foraging may have a significant impact on macroinvertebrate biomass. We suggest that future studies focus specifically on high use areas to better determine threshold foraging densities that impact macroinvertebrate availability would be encouraged. Furthermore, more definitive research is needed in the LMAV to determine if shorebirds are selectively feeding on certain taxa.

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